Health Status Assessment via the World Wide Web

Douglas S. Bell, M.D., Charles E. Kahn, Jr., M.D.

Division of General Internal Medicine, UCLA Medical Center, Los Angeles, CA;
Section of Information and Decision Sciences, Department of Radiology,
Medical College of Wisconsin, Milwaukee, WI

We explored the use of the World Wide Web to collect health status information for medical outcomes research. The RAND 36-Item Health Survey 1.0 (RAND-36), which contains the 36 multiple-choice questions of the Medical Outcomes Study SF-36 "Short Form" and differs only in its simplified scoring scheme, was made available for anonymous use on the Internet. Participation in the survey was invited through health-related Internet news groups and mailing lists. Participants entered data and received their scores using the World Wide Web protocol. Entries were recorded from 15 June 1995 to 14 June 1996 (1 year). The survey was completed anonymously by 4876 individuals with access to the World Wide Web. Two-thirds completed the survey within 5 minutes, and 97% did so within 10 minutes. The item-completion rate was 99.28%. Values of Cronbach's alpha of 0.76 to 0.90 for the scoring scales matched the high reliability found in the Medical Outcomes Study. The World Wide Web provides a method of rapidly measuring individual health status and may play an important role in advancing health services research and outcomes-based patient care.

INTRODUCTION

The nationwide transition to managed care creates a growing need for efficient, routine outcomes monitoring. Outcomes data are needed to support quality-improvement efforts within health care institutions, to compare competing institutions, and to demonstrate accountability to corporate and governmental purchasers [1,2] . Beyond indices such as mortality, cost, and the absence of disease, there is growing consensus that the patient's view of his or her own health is a primary outcome for measuring the quality of care [3,4] .

Standardized instruments for the assessment of health status are crucial for comparing results among studies and institutions. Instruments that address general health concepts such as functioning and emotional well-being have the broadest applicability [5] . The Medical Outcomes Study's SF-36 "Short Form" was formulated to create a brief, comprehensive, standardized, and psychometrically sound survey of health status [6,7] . The SF-36 assesses physical and emotional aspects of health, has been validated extensively, and has been applied in numerous medical outcomes studies [7,8] . The routine use of instruments like the SF-36 has been limited, however, by the expense of administering and then analyzing the results of paper-based questionnaires.

The World Wide Web (WWW, or simply the "Web") has become an increasingly important medium for rapid, international dissemination of information [9] . It allows multimedia data—such as text, images, illustrations, audio, and video—to be transmitted from a source computer ("server") to a destination computer ("client") via the Internet, a network of networks that forms today's "information superhighway." The Web has become an important medium for research, education, patient care, and international collaboration in medicine [10-12] . Although currently the Web is used primarily to disseminate information, it also can collect information from users [13] .

We explored the use of the World Wide Web as a platform-independent method of collecting health status information. The Web is "platform independent" because its functionality does not depend on the specific type of computer hardware or software used by either the client or the server. Data-entry forms written in the Web's hypertext markup language (HTML) can fulfill all of the functions of a paper-based survey, including standardized selectable items and free-form text entry fields. Web client programs such as NCSA Mosaic (National Center for Supercomputing Applications, University of Illinois, Urbana, IL) and Netscape Navigator (Netscape Communications Corp., Mountain View, CA) provide graphical, point-and-click access to multimedia Web information. Users can view a document and fill out a survey by pointing and clicking the mouse button. Web client programs are available for computers with Apple Macintosh

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(Apple Computer Co., Cupertino, CA), Microsoft Windows (Microsoft Corp., Redmond, WA), and X-windows operating systems (numerous vendors).

METHODS

The RAND 36-Item Health Survey 1.0 (RAND-36) was converted into the Web's HTML format; this survey contains the 36 multiple-choice questions of the SF-36 "Short Form" and differs only in its simplified scoring scheme [14] . The wording of each question was preserved exactly, including the use of boldface type. The multiple-choice response options on the paper forms were represented as radio buttons—"clickable" response items presented in groups, where only one item from the group can be selected at any time. None of the buttons was pre-selected by default.

Two versions of the questionnaire were prepared. The "Plain" version presented the choices in a list beneath each question. The "Table" version included HTML version 3.0 table-formatting capabilities to present the information in a more compact format; for many items, the question and answers were presented in the same row (Figure 1).

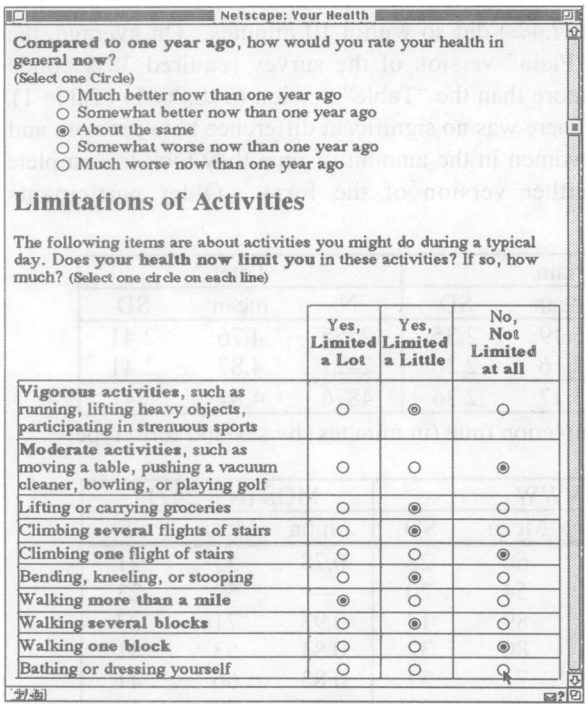

Figure 1. Example screen from RAND-36.

A "home" page (*http://www.mcw.edu/midas/health*) described the questionnaire and its experimental nature, and encouraged users to participate. Each user was required to enter his or her age and sex, to accept the terms of the disclaimer, and to indicate whether or not the Web client program ("browser") could display tables. The user then submitted this form by pressing the "Proceed to Survey" button.

The system validated the information submitted. It rejected any entry with age less than 18 years or greater than 99 years, if neither "male" nor "female" was entered, or if the user did not accept the disclaimer. If the entry was rejected, the user was so informed, and could return to the home page to revise the information. For valid entries, the program transmitted the RAND-36 form in either the "Table" or "Plain" format, according to the preference specified by the user. The form's instructions urged the user to answer the survey completely, honestly, and without interruption.

Users entered their responses by clicking on the appropriate radio buttons, and pressed the "Done" button at the bottom of the form when finished. Upon pressing this button, the user's age, sex, form type, and responses to the questionnaire items were transmitted to the server computer. The system recorded this information, interpreted the responses, and calculated the scores for the nine categories. The recorded information included an encrypted version of the user's Internet Protocol (IP) address; this encrypted address, combined with the age and sex, was used to identify each participant uniquely without knowing that person's identity or institutional affiliation. The system also recorded the time at which the questionnaire was transmitted to the user and the time at which the user completed the questionnaire.

The system generated a document that included the user's scores, the percentile rankings for the scores, and the mean and standard deviation of the MOS study population; this document was returned to the user for viewing. Percentiles were estimated using the z-value of the user's raw score assuming a normal distribution based on the MOS population's mean and SD. The document also included links to additional information about the RAND-36 and SF-36 surveys, including a bibliography with abstracts of relevant journal articles.

We prospectively established criteria for rejecting entries from the study. "Repeat" entries, defined as those where the user's address, age, and sex matched those of a earlier respondent on the same day, were excluded. We excluded entries with fewer than 18

answers or those submitted more than 40 minutes after the form was transmitted initially. Entries from 15 June 1995 to 14 June 1996 (1 year) were analyzed.

The availability of the survey was announced to several health-related electronic mailing lists and Usenet news groups, the NCSA and Netscape "What's New?" services, and Yahoo's "General Health" Web index (*http://www.yahoo.com*). We conducted exploratory data analyses of the age and sex distribution of the participants, the completeness of the surveys, the time to complete the survey (by sex, age group, and form type), and the characteristics of the scores. Means were compared using the unpaired, two-tailed t-test assuming unequal variances. Logistic regression and calculations of mean, standard deviation (SD), t-test, and Cronbach's alpha were performed using the Stata statistical analysis package, version 3.0 (Stata Corp., College Station, TX).

All documents and programs were developed on a DEC 5000/25 computer with the ULTRIX V4.4 (Rev. 69) operating system (Digital Equipment Corp., Maynard, MA) running the NCSA 1.4 httpd server program (University of Illinois, Urbana, IL). The programs were written in the Perl programming language (version 4) and were linked to the WWW server using the Common Gateway Interface (CGI) 1.1 protocol. Several test entries demonstrated the accuracy of the data-entry mechanism and scoring software.

RESULTS

A total of 5642 entries were received. We excluded 57 test cases, 637 "repeat" entries or entries with no item responses, 51 entries with too few answers, seven entries that exceeded the time limit, and 14 entries that lacked demographic information. The 4876 valid entries originated from 4792 individuals (persons of the same age, sex, and encrypted Internet address) at 4296 unique sites. Of the 75 "individuals" who sent repeat entries on different days, none participated more than four times. Some or all of these may in fact represent different individuals. Independent, aggregate analysis of the Web server's log showed that entries had been received from 44 countries; 2257 sites (53%) had U.S. commercial or educational addresses.

The participants included 2455 men (50.3%), age 18 to 97 years (mean ± SD, 38.2 ± 11.4 years), and 2421 women (49.7%), age 18 to 87 years (34.8 ± 10.7 years). The survey was answered completely by 3002 participants (87.7%); the overall item-completion rate was 99.28%.

About two-thirds of the participants (3214; 65.9%) completed the survey within 5 minutes, and 4748 (97.4%) did so within 10 minutes. On average, the "Plain" version of the survey required 38 seconds more than the "Table" version ($p<0.0001$) (Table 1). There was no significant difference between men and women in the amount of time they took to complete either version of the form. Older participants

	Table			Plain			Total		
Sex	N	mean	SD	N	mean	SD	N	mean	SD
Male	1667	4.56	2.41	788	5.19	2.35	2455	4.76	2.41
Female	1301	4.62	2.41	1120	5.16	2.36	2421	4.87	2.41
Total	2968	4.59	2.41	1908	5.17	2.36	4876	4.81	2.41

Table 1. Mean and standard deviation (SD) of survey-completion time (in minutes) by sex and form type.

		WWW				MOS (N = 2471)		
Scale	Items	N	Alpha	Mean	SD	Alpha	Mean	SD
General Health	5	4876	0.78	66	22	0.78	57	21
Health Change	1	4870	—	54	20	—	59	23
Physical Functioning	10	4874	0.90	89	17	0.93	71	27
Limitations / Physical	4	4853	0.83	80	32	0.84	53	41
Limitations / Emotional	3	4863	0.76	71	37	0.83	66	41
Social Functioning	2	4870	0.85	82	22	0.85	79	25
Pain	2	4866	0.84	79	20	0.78	71	26
Energy / Fatigue	4	4859	0.89	56	21	0.86	52	22
Emotional Well-Being	5	4859	0.84	69	18	0.90	70	22

Table 2. Reliability, central tendency, and variability of RAND-36 scales in the self-selected Web population (WWW) and Medical Outcomes Study (MOS) population.

required more time to complete both form versions; participants of age 50 years or more required 37 seconds more than younger individuals (p=0.0001).

The calculated scores showed a high degree of reliability in our population as evidenced by values of Cronbach's alpha of 0.76 to 0.90 (Table 2). Correlation of the General Health scale with the other scales ranged from 0.27 (Health Change) to 0.64 (Energy/Fatigue). Logistic-regression analysis (using binary variables for time, age, and the scoring scales that indicated whether or not the original value was above the median) indicated that only age, form type, Physical Functioning score, and Social Functioning score had significant influence (at p<0.05) on form-completion time; there was no significant influence by sex or by the other scoring scales. Individuals with above-median Physical Functioning and Social Functioning scores completed the survey more rapidly than those with poorer scores (36.4 seconds and 33.5 seconds faster, respectively, both with p<0.0001); this relationship was seen with both form types and across age groups.

Our self-selected population of Web users reported generally better health—especially better physical health—than participants in the Medical Outcomes Study (Table 2). Mean scores indicated significantly better health among Web users (p<0.0001) for all scales except Health Change and Emotional Well-Being. Web users' scores were almost 1 standard deviation higher for Physical Functioning and Role Limitations due to Physical Health. Health Change scores were slightly but significantly lower in our population (p<0.0001). There was no significant difference between populations (even at the p=0.10 level) in the Emotional Well-Being score.

DISCUSSION

This study demonstrates use of the World Wide Web to efficiently capture personal health status information. That 97% of users completed the survey in less than 10 minutes attests to the ease of use of the RAND-36, our form layout, and the Web software. Further evidence that the form layout provides a small but statistically significant effect on ease of use is the fact that users of the form's "Table" version spent on average 10% less time entering data than did users of the "Plain" version. Individuals over 50 years of age and those with below-average physical-functioning scores took on average about 10% longer at the task. These differences were statistically significant, but probably would not present significant obstacles to more general implementation. Patients with more severe limitations, however, might need others to help them enter the information, just as they would need someone to help them with a physical form. There were no significant sex differences in data-entry time despite the large sample size.

Use of the Web for data collection provides advantages over paper-based form administration. Individuals at geographically remote sites can enter information rapidly using a simple, easily learned, graphical interface. Costs of data entry are low because Web client programs are available for almost every available computer hardware platform so survey administration can take place using existing infrastructure. A user's survey results are available electronically for immediate reporting, database storage, and aggregate analysis. The Web's security and encryption features can be used to protect the confidentiality of patients' responses without the need for a secure, limited-access communications channel. Such security features are available from commercial vendors, and these features are being used for secure transmission of financial information such as credit-card numbers.

Both Web-based and paper-based methods of data collection raise the issue of authenticating self-reports. Although we could not verify directly any individual's answers to the RAND-36 items, the answers given showed a high degree of internal consistency, as evidenced by values of Cronbach's alpha from 0.76 to 0.90. These values were comparable to those found for the same scales in the Medical Outcomes Study, and suggest that answers given on our survey were at least consistent, if not truthful.

The chief disadvantage of using Web-based data collection is limited access. The users reported in this study already had Web access for reasons other than providing health information. Although Web use is growing exponentially [9] , most elderly and unemployed patients will remain without easy access for the foreseeable future. These patients would need to use Web-based surveys at their physician's offices, but this location would require efficient use of a shared resource.

Most participants were quite efficient, averaging less than 10 seconds per question, but older users and those with self-reported lower functioning required more time. Our preliminary data from another study

indicate that elderly outpatients who are first-time computer users need 20–30 seconds per question, with supervision, while learning the survey task. Patients with more severe functional disabilities might require substantial assistance with either paper- or Web-based surveys. In some cases, a friend or family member might provide information as a proxy for the disabled patient. In many cases, the data may be valuable enough to justify an interviewer filling out the survey for those who can't learn to do so efficiently. Further work is needed to explore the integration of Web-based patient surveys into routine outpatient care.

The Internet and the World Wide Web are poised to transform the delivery of health care [15] . Beyond Kassirer's prediction that patients will obtain an increasing proportion of their health information without physically visiting a physician [15] , the current study demonstrates that an equally transforming change could occur in the flow of information from patients to providers. Web technology could be applied easily to a variety of survey and data-collection instruments employed in the delivery of health care, including patient history forms, personality inventories, psychiatric symptom questionnaires, and patient satisfaction surveys. World Wide Web could thereby become a key enabling technology in the development of the computer-based patient record [16] . The use of Web technology to administer patient surveys could dramatically lower the cost of performing both randomized clinical investigations and routine outcomes monitoring. As a result, the World Wide Web may play an important role in advancing health services research and outcomes-based patient care.

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